Orbiter
April 2018

A Glimpse of the Future Today: HoloLens and the "Internet of Things"

by **Eric Cheevers**
April 24, 2018

Graham Johnson of the Visualization and Immersive Tech Department demonstrates the Microsoft HoloLens (Photo: Elisa Haber)

The term "Internet of things" was coined by Kevin Ashton of Procter & Gamble (later MIT's Auto-ID Center) in 1999. While prescient, the concept's popularity was initially limited to the Auto-ID Center at MIT and related market-analysis publications. In the past few years, however, the term has become increasingly ubiquitous.

The Internet of Things (IoT) refers to the interconnection, via the Internet, of computing devices embedded in everyday objects, such as vehicles, home appliances, and other items, enabling these objects to send and receive data. Objects of quotidian use are increasingly embedded with electronics, as well as software, sensors, and actuators, allowing these objects to be remotely sensed and/or controlled across the current network infrastructure, and to autonomously exchange useful data amongst themselves.

While there are justifiable concerns regarding the security of connected systems, the IoT is nonetheless an impending reality. By 2020, the IoT is expected to comprise approximately 30 billion connected devices, with the estimated global market value of IoT reaching $7.1 trillion that same year, according to published academic papers on the subject of IoT.

The advent of smart homes, smart workspaces, smart transport and smart cities is nigh, and the IoT is laying the groundwork for this imminent future now.

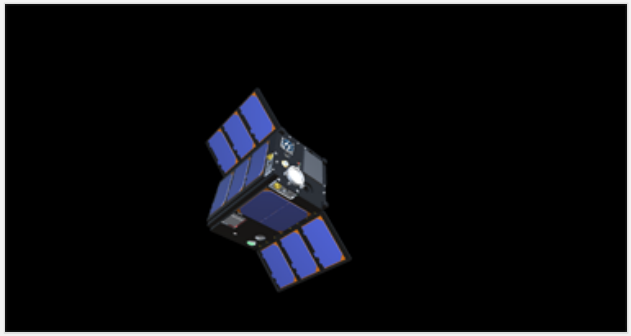
It is important to note that the IoT encompasses a broad range of devices, with far wider-reaching potential and implications than one might think. IoT devices also include medical implants, DNA analysis devices for environmental/food/pathogen monitoring, field operation devices that assist firefighters in search and rescue operations, and biochip transponders in livestock animals, to name a few. In this instance, the IoT offers the potential for far more direct integration of the physical world into computer-based systems, ideally increasing efficiency, accuracy and economic benefits, while reducing the need for actual human intervention. When the IoT is implemented in this capacity, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as virtual power plants, smart grids, intelligent transportation and smart cities.

A recent Aerospace "Internet of Things Open House" event featured demonstrations of data collection using distributed sensor networks, with data subsequently analyzed via computer vision and Spark processes, then visualized with web interfaces and JavaSTARS. Among the networked devices on display was the highly anticipated Microsoft HoloLens; a head-mounted holographic computer serving as a pair of "mixed reality" smartglasses, enabling a user to perceive and interact with visual data overlaid upon one's field of vision.

The front portion of the HoloLens contains sensors and related hardware, including the cameras and processors. The visor itself is tinted, and contains a pair of transparent combiner lenses, in which the projected images are displayed. Near the user's ears are a pair of small, red 3D audio speakers, allowing the user to hear virtual sounds along with their actual (non-virtual) environment. Using head-related transfer functions, the HoloLens generates binaural audio, which can simulate real-world spatial effects. Most notably, the user can perceive and locate a sound spatially as though it is coming from a virtual pinpoint or location, much as it would in the real world.

The HoloLens is self-contained, rechargeable, and is not tethered to a desktop for processing power. Though still in the development phase, it's potential has already come to fruition in the following applications:

- *Cortana*, Microsoft's virtual assistant.
- *HoloStudio*, a full-scale 3D modeling application by Microsoft with 3D print compatibility.
- User manipulation of holographic, 3D objects that users can place and scale around them, enabling compelling virtual presentations that can be attended by multiple attendees remotely.
- An implementation of the Skype telecommunications application in which PC or mobile device Skype users can view what a HoloLens user is seeing, while the HoloLens user will see view captured by the PC or mobile device user's camera.
- *HoloTour*, an audiovisual three-dimensional virtual tourism
- *SketchUpViewer*, a set of architectural engineering software design tools.
- Fragments, a high-tech crime thriller adventure game developed by Microsoft and Asobo Studio, in which the player engages in crime-solving.
- *Young Conker*, a platform game developed by Microsoft and Asobo Studio.
- *RoboRaid* (previously code-named "Project X-Ray"), an augmented-reality first-person shooter game by Microsoft in which the player defends against a robot invasion, aiming the weapon via gaze, and shooting via the Clicker button or an air tap.
- *Actiongram*, an application for staging and recording short video clips of simple mixed-reality presentations using pre-made 3D virtual assets.



A HoloLens view of the AeroCube 7

While the prospect of a future populated by interconnected devices seems daunting, the potential of sharing 'blended' environments comprising real and holographic elements has undeniable potential, most notably in the ability to share perspectives (literal and figurative) with people across the globe. When sharing ideas and designs, it is often easier to show than it is to tell, and the HoloLens seems poised to facilitate this process.

Though the concept of the IoT can seem dystopian, the prospect of mixed reality bringing people, places, and objects from the physical and digital worlds together can and should foster growth, innovation, and understanding, while eliminating the barriers of time, distance, and communication. While the HoloLens' full potential is not yet realized, the unique, blended environment it offers bears witness to the viability of the IoT, and to its imminent ascendancy.

TESS Orbits Our Planet, Looks for Others

by **Laura Johnson**
April 18, 2018

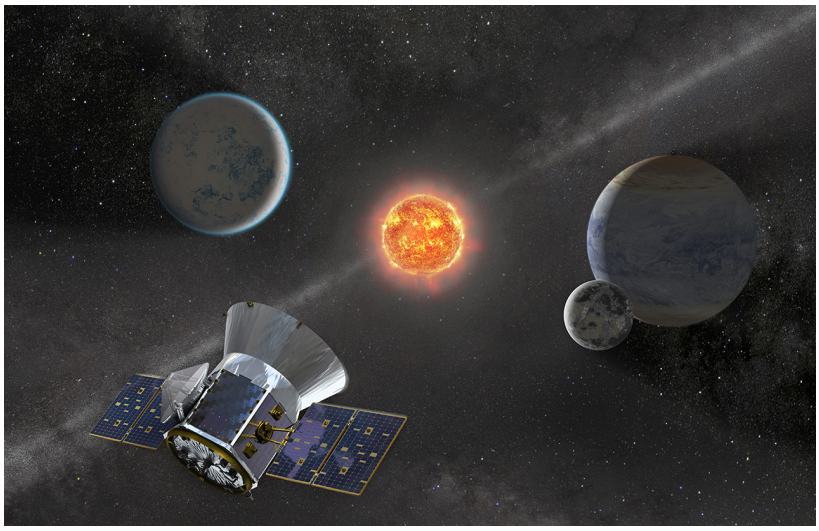


Illustration of TESS observing an M dwarf star with orbiting planets. (Credit: NASA's Goddard Space Flight Center)

What goes around, comes around … every 13.7 days.

An Aerospace team helped develop the orbit for NASA's recently launched Transiting Exoplanet Survey Satellite (TESS), which will look for exoplanets, that is, planets outside our solar system.

The two-year mission, which launched April 18 from Cape Canaveral Air Force Station on a Falcon 9, will examine more than 85 percent of the sky, looking for planets orbiting 200,000 of our brightest neighboring stars.

According to NASA, "TESS will operate on a unique high Earth orbit in a 2:1 resonance orbit with the Moon, which has never been used before. The orbit was tailored for the TESS mission by engineers at NASA's Goddard Space Flight Center and The Aerospace Corporation."

TESS' planet-hunting technique is to stare at a distant star to determine if tiny reductions in light can be observed — indicating that a planet has passed in front of the star. As the TESS team was weighing mission design options to do this, it became apparent that the orbit chosen for the TESS spacecraft would play a critical role in achieving a successful mission.

The Orbit

Aerospace collaborated with team members in the development of an orbit called a "P/2 HEO" orbit, which has that name because it is a highly elliptical orbit with an orbital period half that of the moon (i.e., 13.7 days).

This orbit allows the TESS spacecraft to spend lengthy periods far from earth to give unobstructed views of the celestial sphere while avoiding or controlling for stray light from the earth, sun and moon. It also minimizes gravitational perturbations from the moon and earth, and provides a low radiation, thermally stable environment for its four wide-field-of-view cameras.

These factors combine to help produce unobstructed continuous viewing opportunities with extremely stable pointing, which is necessary to achieve the planet-hunting mission.

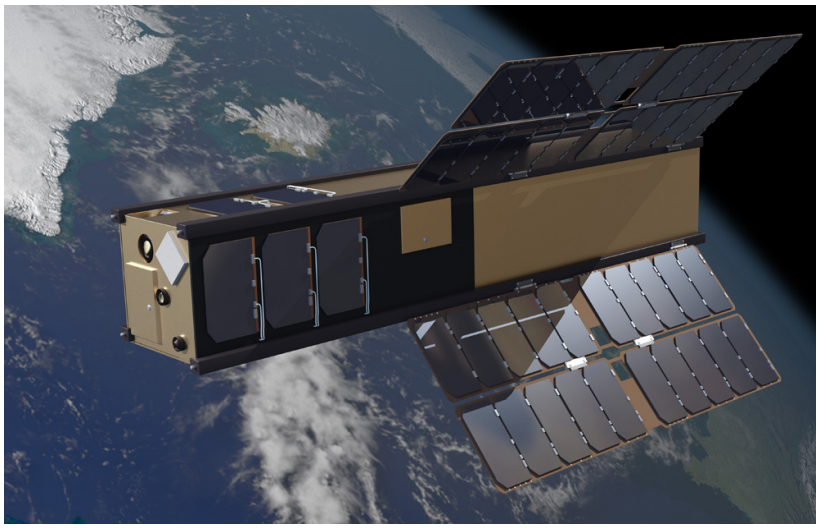
TESS is expected to discover around 20,000 planets, including some the size of Earth. According to NASA, "TESS will find the most promising exoplanets orbiting our nearest and brightest stars, giving future researchers a rich set of new targets for more comprehensive follow-up studies."

To learn more about TESS, check out NASA's website.

Improving Atmospheric Models With DAILI

April 05, 2018

NASA has awarded Aerospace $2.85 million to investigate dynamic changes in the Earth's atmosphere and ionosphere. The centerpiece of the study is an instrumented six-unit CubeSat mission called the Daily Atmospheric Ionospheric Limb Imager (DAILI), that will be designed, built, and flown by Aerospace. DAILI is scheduled to begin its one-year flight mission in 2020.



The Daily Atmospheric Ionospheric Limb Imager (DAILI) will be designed, built, and flown by Aerospace (Illustration by Joseph Hildago)

DAILI will study the atmosphere at an altitude range of about 140 to 290 kilometers. In this region, measurements are scarce, and density and composition are highly variable. This variability affects the plasma and atmospheric structure at higher orbital altitudes. DAILI will provide data for atmospheric models, important for applications such as calculating the precise orbits of satellites and understanding the propagation of radio signals.

"We are pleased that Aerospace was selected to support NASA with the DAILI mission," said Dr. Sherrie Zacharius, vice president of Technology and Laboratory Operations. "Much of the uncertainty in atmospheric models is due to limited understanding of the composition profile in this region, particularly regarding molecular oxygen density. DAILI will provide the specialized data needed to help fill these gaps."

The technique DAILI will use was validated by previous measurements made by Aerospace's photometer portion of the Remote Atmosphere/Ionosphere Detection Sensor (RAIDS), which was deployed on the International Space Station. DAILI provides the same capability as RAIDS in a miniature form.

DAILI is envisioned as a linear six-unit (10x10x60 cm) CubeSat. The forward three-unit long sunshade of the CubeSat reduces intense scattered light from the sun, the earth, and low altitude clouds by a factor of a trillion. This reduction will allow the measurement of the faint images seen by DAILI. A rear three-unit section contains the optical payload and the avionics.

The DAILI mission will complement two future NASA satellite missions, ICON and GOLD, to be launched in 2018.

New Rocket Motor Takes Flight

by **Laura Johnson**
April 02, 2018

Solid, liquid, or gas? That might sound like a question on your high school physics test, but it's an important consideration when powering a rocket into space.

A team from Aerospace successfully tested a new type of 3-D printed rocket motor that could potentially lead to less expensive and more efficient rocket propellants.

"The Aerospace Corporation created and has led the field of 3-D printed propellant from its beginning, but we've never flown any of the technologies we created in this area," said Jerry Fuller, who came up with the idea in the first place. "This test was the first flight of a novel liquid motor."

Propulsion Options

Traditionally, there are several types of rocket propulsion systems. Liquid propellants are the most capable, but also the most expensive. Solid propellants are simple, inexpensive, and common. Hybrid propellants (combining solid fuel with a liquid or gas oxidizer) are reasonably inexpensive, but are rarely used since they don't perform very well.

"The truth is hybrids don't burn fast enough and are not as efficient as they should be," Fuller said.

Fuller has been investigating ways to 3-D print hybrid motors, and has come up with helical shapes that enable the liquid or gas oxidizer to interact with the solid fuel more effectively and dramatically improve performance.

Not satisfied to stop there, he is now looking at what he calls "Port Injected Liquid" motors. Normally, liquid motors require expensive turbopumps to deliver the fuel and oxidizer. Fuller rearranged the traditional structure of a liquid motor, where the fuel and oxidizer are pumped from low pressure tanks into a thrust chamber, to look more like that of a hybrid rocket, where liquid oxidizer flows through a chamber that contains solid fuel. Here, a printed "liquid fuel grain" stores a liquid fuel and meters the flow of fuel as the oxidizer passes through it. This arrangement can eliminate much or all of the plumbing and turbomachinery typically seen in liquid motors. It also allows liquid motors to be very small and simple and inexpensive.

A 3-D printed fuel grain ready to be filled with liquid fuel.

Fuller and systems engineer John McVey cooked up the idea to test these motors, and they pulled in propulsion science engineer Andrew Cortopassi and amateur high-power rocketry wonk Chris Kobel to complete the task. With Cortopassi's expertise, the team first tested the motors in Aerospace's Propulsion Research Facility, and then decided it was time for the motors to, quite literally, take flight.

They packed up their gear and took a field trip to California's Mojave Desert, where they launched four of their liquid motors and one hybrid motor on high-power hobby rockets. They expected to reach an altitude of 1,000-4,000 feet, but one of the liquid motors exceeded their expectations, reaching a maximum altitude of a little over 5,000 feet, with a maximum velocity of almost 600 mph. These results bode well for the future.

Looking Forward

Fuller emphasizes that the research thus far has been for small motors, like the ones just tested in the Mojave Desert. Larger motors would need to be tested, but with current 3-D printers, creating a fuel grain for a sounding rocket or a small CubeSat launch vehicle is not out of the realm of possibility.

More research is needed, but the potential for a less-expensive, high-performance motor is attractive. As Fuller puts it:

"A simple liquid motor is something that doesn't really exist at the moment, and if we can find ways, probably through 3-D printing, to manage the delivery of liquid fuel, then we will have made a significant advance in rocket motor technology," he said. "At the moment it looks like we have found at least one of these ways."

Fun and Wonder at Take Our Kids to Work Day

by **Gabriel A Spera**
April 30, 2018

The new hires get younger every year—but these kids will still have to get through college before joining the Aerospace team. (photo: Elisa Haber)

Shouts and laughter filled the air on Thursday, April 26, as a swarm of school kids descended on Aerospace, bringing with them enough energy to launch a Falcon Heavy. It was the annual Take Our Kids to Work Day, and Aerospace showed that its commitment to excellence extends to STEM events, too.

Highlights of the day included opening remarks from president and CEO Steve Isakowitz, who explained the importance of the Aerospace mission in terms even a child could understand.

The kids had a full slate of activities scheduled throughout the day. In El Segundo, they visited the virtual reality lab, the drone facility, the STARS Mission Control Center, and the ever-popular cryogenics lab—where they discovered how hungry scientists make ice cream. They also learned about space junk and orbital modeling, tried on space gloves, made slime, launched mini rockets and controlled robot cars. In Crystal City, kids enjoyed the egg-drop competition, devising ways to drop eggs from the rooftop without breaking them. They also built Lego rockets, examined a CubeSat, and learned about life as an astronaut. In Chantilly, kids built Lego models of the space shuttle, destroyed some paper in the classified document destruction room, and built a simple model circuit. They also constructed rockets and launched them at a target across the auditorium.

This was the largest Aerospace Take Our Kids to Work day ever, with more than 170 kids in El Segundo, 48 in Chantilly, and 10 in Crystal City—plus an army of volunteers and chaperones.

34th Annual Space Symposium Wraps in Colorado Springs

by **Wendy O'Dea**
April 20, 2018

The Aerospace team gathers for the kick off of the 2018 Space Symposium. (Photo: Kelly Hart)

The 34th annual Space Symposium wrapped up Thursday, April 19, in Colorado Springs. As always, this four-day whirlwind of meetings, panels and presentations was exciting and fruitful for The Aerospace Corporation.

Vice President Mike Pence delivered remarks at the event launch on Monday, speaking to the United States' reinvigorated agenda on space, including both a promise to send humans to Mars, as well as a renewed effort to streamline regulations and encourage innovation in the industry. The vice president

discussed the work of the National Space Council, as well as the National Space Strategy announced by the president last month.

In his remarks, the vice president also emphasized the urgent need for greater attention to space traffic management, saying "President Trump knows that a stable and orderly space environment is critical to the strength of our economy and the resilience of our national security systems. And that's why the National Space Council has developed the first comprehensive space traffic management policy, which we will soon be sending to the president's desk for his approval."

Vice President Pence speaks at the 2018 Space Syposium (Photo Courtesy of Space Foundation)

On Monday evening, the Aerospace contingent gathered to hear comments from CEO Steve Isakowitz, meet coworkers from other offices, and take a group photo before the show kicked off.

Aerospace held several events throughout the week, presenting the company's work, as well as supporting discussion around several areas that the industry is grappling with during a time of rapid change. Tuesday afternoon's Global Space Exploration Panel, moderated by Senior Vice President Ed Swallow, brought together representatives from NASA, international partners, and the industry to discuss the challenges and opportunities each organization sees before them.

On Wednesday afternoon, Aerospace held two media briefings that presented some of the company's most recent and relevant work to journalists attending Space Symposium. Jamie Morin, Marlon Sorge and Andrew Abraham, all members of the Center for Space Policy and Strategy team, were joined by retired Admiral Cecil Haney to discuss the pressing problem of congested space and progress in the area of space traffic management. Journalists were excited to learn more about the topic, especially given the attention the vice president gave the matter in his Monday remarks.

Later that afternoon, Randy Villahermosa, who heads the Aerospace iLab, along with Richard Yau, Carrie O'Quinn and Andre Doumitt, spoke to reporters about how the spirit of innovation found in the tech sector can be applied to the work we do on space. Journalists were interested to hear about several of the projects the panel highlighted, including Launch-U and Pawn.

Late on Wednesday afternoon, Randy Kendall, vice president of Launch Program Operations, moderated an extremely well-attended panel on the Promise of Agile Launch. Kendall skillfully facilitated discussion among industry experts, including representatives from Aerojet Rocketdyne, Virgin Orbit, and Vector Launch, as well as leaders from the Air Force and DARPA.

Throughout the week, the Aerospace booth was hopping. A roster of dedicated colleagues gave visitors an overview of our work and made and renewed connections with some of the industry's most important players. Sore feet and hoarse voices were the price to pay for some, but the Aerospace team performed remarkably over the course of the week at Space Symposium, making the event a success for our company on all fronts.

Press Release: Aerospace Highlights the Future of Space Innovation at Space Symposium

April 12, 2018

EL SEGUNDO, Calif. (April 12, 2018) – The Aerospace Corporation (Aerospace) will highlight its unique technical expertise and capabilities in developing innovative space technologies for national security and support of space traffic management, mission assurance, space exploration, and human space flight at the 34th Space Symposium, which runs from April 16-19 in Colorado Springs, Colo.

"Aerospace is helping shape our nation's space enterprise with data-driven solutions and options that are innovative, resilient, and timely," said Steve Isakowitz, Aerospace president and CEO. "Through these efforts, we will ensure that the U.S. is positioned to confront evolving threats and leverages promising opportunities across the various domains of space.

Aerospace's press kit for Space Symposium will include fact sheets, executive biographies, and related materials to the media briefings and panel discussions at the show.

Note: All briefing and panel discussion times listed below are local to Colorado Springs (Mountain Time):

TUESDAY, April 17 – Location: The Broadmoor Hotel's Golf Club/Robert Trent Jones Room

2:00 p.m. – 5:00 p.m. | Global Space Exploration Panel

The Aerospace Corporation will kick off a discussion with NASA, various commercial entities, and international agencies about the global space exploration vision, challenges, and partnerships that will be required to achieve a variety of goals.

Featured panelists will include: Edward M. Swallow (moderator), senior vice president, Aerospace's Civil Systems Group, leaders from NASA's International Space Station, Exploration, and Technology Directorates, commercial services–supply and transportation entities, and international partners from the European Space Agency and Canadian Space Agency.

WEDNESDAY, April 18 – Location: The Broadmoor Hotel's Golf Club/Robert Trent Jones Room

1:00 p.m. – 2:00 p.m. |Space Traffic Management in the Age of New Space

Learn more about the global space traffic management trends, policies, and new technologies designed to encourage responsible behaviors in space. Get a first look at newly published research from Aerospace experts on GPS transponders in space, space traffic management, remote proximity operations, and much more.

Featured panelists: Dr. Jamie Morin (moderator), executive director, Center for Space Policy and Strategy; **Adm. Cecil Haney, USN (Ret.),** commander of U.S. Strategic Command, 2013 – 2016, Senior Advisory Council Member, Center for Space Policy and Strategy; **Dr. Andrew Abraham,** senior member of the technical staff, author of *GPS Transponders for Space Traffic Management*; **Dr. Marlon Sorge**, senior project engineer, author of *Space Traffic Management in the Age of New Space*.

2:00 p.m. – 3:00 p.m. | Innovating in Space the Tech Sector Way

Much of the basic innovation philosophy that drives the tech sector—modularity, open-source, common standards—is finding a new life in space. As the spotlight on space resiliency and affordability becomes more intense, increasing the tempo for technology refresh will be a key enabler. Aerospace has created a new portfolio of innovation projects under its iLab initiative to accelerate space enterprise innovation.

Featured panelists: Randy Villahermosa (moderator), executive director of Innovation; **Richard Yau,** senior engineering specialist; **Carrie O'Quinn,** senior project engineer, **Andre Doumitt,** director of Innovation Development.

WEDNESDAY, April 18 – Location: The Broadmoor Hotel – International Center: South

4:00 p.m. – 4:50 p.m. – Panel: The Promise of Agile Launch

What are the enabling elements needed to achieve a truly successful agile launch operation? Join leading industry experts as they discuss the opportunities and challenges of agile launch services and the market implications for the commercial sector.

Featured panelists: Randolph Kendall (moderator), vice president, Launch Program Operations, The Aerospace Corporation**; Joseph Cassady**, executive director, Space, Aerojet Rocketdyne; **Dr. Fred Kennedy**, director, Tactical Technology Office; Defense Advanced Research Projects Agency; **Brig. Gen. Wayne R. Monteith**, commander, 45th Space Wing, and director, Eastern Range, Patrick Air Force Base, U.S. Air Force; **Dr. George C. Nield**, former associate administrator for commercial space transportation, Federal Aviation Administration; **Greg Orndorff**, director, government launch sales, Vector Launch, Inc.; **Dan Hart**, president and CEO, Virgin Orbit.

April 2018 Obituaries

by **Jessie Ding**
April 01, 2018

Sincere sympathy is extended to the families of:

Elden Arrowsmith, member of technical staff, hired Oct. 7, 1967, retired Sep. 1, 1989, died Feb. 9, 2018
Joseph Chism, member of administrative staff, hired Aug. 6, 1979, retired June 1, 2006, died Mar. 19, 2018
Edward B. Diamond, member of administrative staff, hired Mar. 17, 2008, retired Aug. 1, 2017, died Feb. 22, 2018
Karen A. Douglas, member of technical staff, hired Feb. 5, 1979, retired Apr. 1, 2008, died Feb. 24, 2018
Elias Exacoustos, member of technical staff, hired Apr. 27, 1981, retired Apr. 1, 2006, died Jan. 13, 2018
Jerome S. Field, member of technical staff, hired Aug. 6, 1962, retired June 1, 1978, died Feb. 26, 2018
Philip Finch, member of technical staff, hired June 5, 1962, retired Aug. 1, 1989, died Mar. 5, 2018

William Fish Jr., member of technical staff, hired Jan 30, 1961, retired Jul. 1, 1985, died Sep. 24, 2017
Gloria Firmin, office of technical staff, hired Nov. 5, 1979, retired Nov. 1, 1991, died Feb. 20, 2018
James Janis, member of technical staff, hired Sep. 5, 1961, retired Mar. 1, 1989, died Feb. 17, 2018
Harold Mc Donnell, member of technical staff, hired Nov. 17, 1960, retired Dec. 1, 1986, died Jan. 20, 2018
Margaret Melton, office of technical staff, hired Oct. 15, 1962, retired Mar. 1, 1986, died Jan. 9, 2018
Linda Pagan, technical support staff, hired May 23, 1997, died Jan. 31, 2018
Earl Parker, member of technical staff, hired Mar. 24, 1997, died Mar. 4, 2018
Lawrence H. Rachal, member of technical staff, hired Oct. 27, 1962, retired Sep. 1, 1989, died Feb. 23, 2018
Eileen J. Royce, member of technical staff, hired July 12, 1982, retired July 1, 2013, died Feb. 26, 2018
William A. Sanberg, member of technical staff, hired Feb. 21, 1961, retired Jul. 1, 1987, died Feb. 19, 2018
Jane Self, member of administrative staff, hired Jan. 18, 1963, retired Nov. 1, 1991, died Feb. 21, 2018
Nina Tsouras, office of technical staff, hired Oct. 7, 1960, retired Nov. 1, 1991, died Mar. 10, 2018
Frank J. Voit, member of technical staff, hired June 26, 1965, retired Mar. 1, 1998, died Feb. 8, 2018

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